Tunnel ventilation and filtration

Fact sheet

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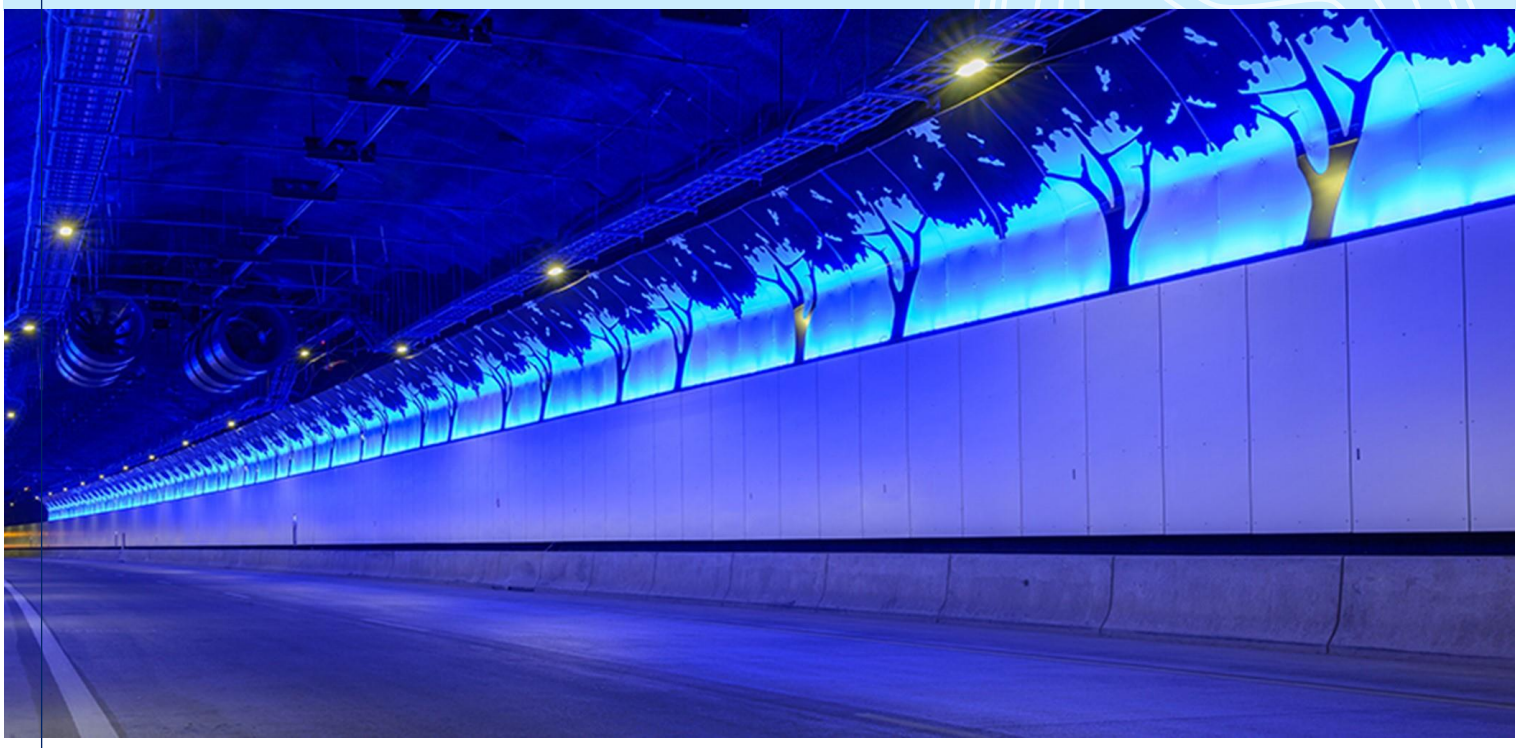

Road tunnels can help reduce air pollution by moving vehicles underground and off the surface roads near where people live and work. Within the tunnel environment, vehicle emissions can be controlled and dispersed more effectively, and the surrounding air quality is subject to monitoring to ensure requirements are met.

We are committed to best practice

The NSW Government recognises that air quality and human health are key priorities when designing and operating road tunnels and we are committed to best practice when delivering our road projects. There are well-established and effective ways to design tunnels and ventilation systems to ensure local or regional air quality is not negatively impacted.

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Strict requirements

Under NSW Government air quality requirements, Transport for NSW must ensure that air quality is appropriately managed inside and outside the tunnel. Tunnel ventilation systems are designed to comply with these air quality requirements, being some of the most stringent requirements in the world. Planning approvals for tunnel projects also require comprehensive air quality monitoring during the operation of tunnels to ensure these requirements are being met.

Vehicle emissions

Advances in vehicle technology and design and uptake of electric vehicles have assisted in a continued reduction in vehicle emissions despite more cars on the road. Electric vehicles produce no tailpipe emissions, have lower running costs than petrol and diesel vehicles, and provide health benefits through lower air and noise pollution. The $633 million NSW Electric Vehicle Strategy (2021) provides initiatives to increase electric vehicle sales to 52% by 2030-31 and help achieve net-zero emissions by 2050.

Cars built after 2013 emit **97% less oxides of nitrogen** than vehicles built in 1976

Diesel trucks built after 2013 emit **92% less particles of matter** than trucks built in 1996

Modern tunnel ventilation

Tunnel ventilation systems are designed to maintain suitable air quality both inside and outside the tunnel.

In-tunnel air quality

In-tunnel air quality is addressed by ensuring sufficient air flow through the tunnel to prevent the build-up of vehicle emissions. This air flow is achieved through a combination of:

- traffic flow - the turbulence created by traffic flow naturally draws air into the tunnel
- tunnel size - larger diameter tunnels enable more air to be drawn in by both traffic and fans
- ventilation design - jet fans are used to draw in additional air when the traffic slows down.

Ambient air quality

Transport for NSW is committed to ensuring the highest standards of ambient air quality when delivering tunnel infrastructure. Tunnel ventilation systems are designed and operated to protect ambient air quality and the health of the community living and working around the tunnels.

Portal emissions and ventilation outlets

The aim of tunnel ventilation is to dilute vehicle emissions by providing fresh air and then removing the exhaust air from the tunnel. Typical tunnel ventilation options to remove exhaust air are via a:

- portal – this is a location where the tunnel carriageway opens to the surrounding environment
- ventilation outlet – these are usually positioned at each exit portal.

Figure 1: Tunnel ventilation through portals

Figure 2: Tunnel ventilation through ventilation outlets

Choosing ventilation option

Choosing the most appropriate ventilation option depends on the specific circumstances of each tunnel project. Regardless of the option selected, tunnel ventilation systems are designed to achieve the same air quality outcomes for communities.

Internationally, most tunnels are ventilated via portals. The measurable impact of portal air emissions on local air quality is generally confined to a distance of 100 to 200 metres around the portal. Portal emissions may result in unacceptable air pollution where people live or work close to the portals. Recent NSW tunnels longer than one kilometre have people living or working close to the portals, and as a result, have been required to have zero emissions from portals.

To achieve zero portal emissions, jet fans draw in air from the exit portal to ensure a net inflow of air at the portal. All tunnel emissions are removed through an elevated ventilation outlet. This is most efficiently done when the ventilation outlet is positioned near the exit portal.

Elevated ventilation outlets are very effective at ejecting tunnel air high into the atmosphere through a combination of buoyancy and speed. This occurs when the warmer tunnel air (heated by vehicles using the tunnel) is ejected upwards at speed through the outlet by fans. As it is warmer than the surrounding air and the tunnel air continues to rise high into the atmosphere through natural buoyancy.

Once in the atmosphere, the ejected tunnel air dilutes hundreds of times as it mixes with the surrounding air and becomes indistinguishable from background air quality.

Ventilation outlets require significant energy to run and can have a substantial visual impact. Where traffic numbers are low, or no one lives or works close to the portals, portal only ventilation can achieve equivalent air quality outcomes as ventilation outlets on heavily trafficked tunnels with people living or working close to the portals.

The effectiveness of any tunnel ventilation design in dispersing tunnel air under all operating and weather conditions is assessed through specialised computer modelling using actual hour-by-hour weather data for an entire year.

Monitoring

Air quality within major NSW tunnels is continuously monitored in the tunnel and at the ventilation outlet to control the ventilation system. This ensures the strict limits outlined in the approval conditions are always complied with.

The ventilation outlets of all current and future operating motorway tunnels in NSW will require an Environmental Protection Licence issued by the NSW Environment Protection Authority. These licences will require tunnel operators to meet air quality limits and undertake air quality monitoring.

Air quality monitoring around operational tunnel outlets confirms that emissions from tunnel ventilation outlets have no material impact on local air quality. Since 2002, planning approval conditions require that air quality monitoring data be made publicly available on the tunnel's website.

Tunnel filtration

Filtration technologies, also known as 'air treatment systems', can be used in addition to ventilation systems to manage various pollutants. However, these units use a large amount of electricity to operate and can only filter a single particulate, as such, they do not lower the concentrations of other pollutants.

There are two main types of filtration:

- Electro-Static Precipitation (ESP) – used to remove particulate matter (PM)
- De-Nitrification (Denox) – primarily used to remove nitrogen dioxide (NO_2).

Several independent assessments have concluded that there is little to no health benefit for surrounding communities in installing tunnel air treatment systems.

Why filtration is ineffective

There are several limitations to the effective performance of filtration and other potential indirect impacts, including:

- technologies are pollutant specific – no combination of available air treatment systems can remove all tunnel air pollutants, and ventilation and dispersion are still required.
- systems can only treat a very small proportion of vehicle emissions in ambient air. As a result, they have limited, if any, effectiveness in improving local air quality.
- requires heavy investment in treatment equipment and additional ventilation capacity. Consequently, the systems are highly energy intensive and expensive to operate.

The treatment of air in road tunnels, State-of-the-art studies and works is an international assessment of tunnel air treatment published in 2017 by the French Government. The report indicated that globally a very small number of air treatment systems are installed, of which few are routinely operated.

Reducing emissions at the source

Ventilation design will continue to be an effective means to manage air quality around tunnels. However, we must continue to reduce emissions at the source. Adopting cleaner fuels and vehicles, including increasing electric vehicle use, reduces emissions at the source, resulting in improved air quality wherever vehicles are used.

Although there are more cars on the road, a number of initiatives have resulted in substantial reductions in total vehicle emissions in the past two decades, including:

- improvements in technologies and design
- clean fleet programs
- smoky vehicle camera systems
- vehicle import duties on second hand cars

Key initiatives to support air quality

The NSW Government will continue to support initiatives to further reduce emissions at the source, such as:

- The NSW Government's $630 million Electric Vehicle Strategy, which will drive sales of electric vehicles to more than 50% of new car sales by 2030-31.
- The multi-billion dollar Zero Emission Buses program to transition 8000 plus diesel and compressed natural gas public transport buses to zero emissions technology.
- Hydrogen hub and refuelling network initiatives to support the deployment of hydrogen vehicles and refuelling stations as part of hydrogen hubs.
- NSW clean air strategy.

Further reading

For more information, including research reports, search 'road tunnel ventilation systems' on the NSW Chief Scientist & Engineer website.